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PLAIN INFORMATION

GREAT FALLS, MONTANA VOLUME I SUN RIVER



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CONTENTS

	<u>Page</u>
Preface	i
Background Information	1
Settlement	1
The Stream and Its Valley	1
Development in the Flood Plain	2
Flood Situation	8
Sources of Data and Records	8
Flood Season and Flood Characteristics	8
Factors Affecting Flooding and Its Impact	9
Obstructions to flood flows	9
Flood damage reduction measures	9
Other factors and their impacts	9
Flood warning and forecasting	10
Flood fighting and emergency evacuation plans	10
Material storage on the flood plain	11
Past Floods	12
Summary of Historical Floods	12
Flood Records	12
Flood Descriptions	13
4 through 18 June 1948	13
May and June 1953	13
7 through 13 June 1964	13
Future Floods	20
Intermediate Regional Flood	20
Standard Project Flood	20
Frequency	20
Hazards of Large Floods	21
Flooded area and flood damages	21
Obstructions	22
Velocities of flow	22
Rate of rise and duration of flooding	24

CONTENTS (Continued)

	<u>Page</u>
Glossary of Terms	25

TABLES

<u>Table</u>		
1	Population Trends	7
2	Historic Flood Peak Discharges - Sun River at Vaughn, Montana	12
3	Flood Plain Reference Data - Sun River	28

PLATES

<u>Title</u>	<u>Number</u>
Basin Map	1
Flooded Area Maps	2-3
Flood Profiles	4
Cross Sections	5-6

PHOTOGRAPHS

<u>Figure</u>		<u>Page</u>
	1964 Flood - Great Falls	Cover
1	Sun River View Upstream Near Upper Limit of Study	3
2	Sun River, Upstream of Central Avenue West Bridge	3
3	Sun River Downstream from Central Avenue West Bridge	4
4	Sun River View Downstream from Near 2nd Avenue S.W.	4
5	View Upstream to Interstate Hwy. Bridge, Sun River	5
6	View Upstream from Bridge at 14th Street S.W., Sun River	5

PHOTOGRAPHS (Continued)

<u>Figure</u>		<u>Page</u>
7	View Upstream to Railroad Bridge, Sun River, Great Falls	6
8	Sun River, Upstream Side of 6th Avenue S.W. Bridge	6
9	6 June 1948, Aerial View to South, Flooding on West Side of Great Falls	14
10	6 June 1948, Aerial View to South, Flooding on West Side of Great Falls	15
11	Rural Area Upstream of Great Falls, June 1964	18
12	Great Falls, 10 June 1964	18
13	1964 Flood - High Water Mark	19
14	1964 Flood - Foundation Damages	19
15	Depth of Potential Floods - 10th Avenue S.W. and Crescent Drive	23
16	Depth of Potential Floods - 10th Avenue S.W. and 14th Street S.W.	23
17	Depth of Potential Floods - 5th Avenue S.W. and West of 21st Street S.W.	24



BASIN MAP
NO SCALE

PREFACE

This report, Volume I, describes the flood characteristics of the Sun River at Great Falls, Montana. A similar report, Volume II, will be prepared at a later date for the Missouri River flood plain at Great Falls. The areas subject to flooding along the study reach of the Sun River are primarily residential with lesser uses by commercial and industrial developments and some agricultural. Severe flooding has occurred on the Sun River flood plain but even worse flooding is possible.

This report was prepared for the guidance of local officials in planning the use and regulation of the flood plain. In addition to accounts of past flooding at Great Falls, two potential floods are used to represent degrees of major flooding that may occur in the future. These two floods, Intermediate Regional and Standard Project Floods, are fully defined in the Glossary and should be given appropriate consideration in planning for safety of development in the flood plain. The two potential floods are shown by flooded area maps that delineate the approximate areas that would be inundated. Flood profiles show the water depths relative to the streambed and an elevation reference is given that can be applied across the width of the valley. Cross sections are presented to indicate ground level across the valley at specified locations and the overlying flood depths. The flood profiles and flooded area data presented are based on existing conditions of the basin, stream and valley when the report was prepared, and are reasonable, not precise, indications of probable occurrences. Urbanization of the drainage basin may increase runoff and flooding. Possible future improvements to control floods are not a consideration of this report. The information in this report does not imply any Federal interest or authority to zone or regulate use of the flood plains; this is a local responsibility. The report provides a suitable basis for the adoption of land use controls to guide flood plain development, with consideration for environmental attributes, and thereby prevent intensification of loss problems. Since it identifies flood problems the report will stimulate the development of other flood damage reduction techniques such as flood control, removal of obstructions and flood proofing, which might be used in an overall Flood Plain Management (FPI) program.

This report was prepared by the Omaha District, Corps of Engineers, in accordance with the authority granted by Section 206 of the Flood Control Act of 1960 (Public Law 86-645) as amended. The study was requested by the Great Falls City-County Planning Board through the Montana Department of Natural Resources and Conservation.

The cooperation of the City-County Planning Board and other local officials in providing assistance and information was most helpful.

Distribution of the report to officials, agencies and individuals concerned with planning in the area covered is made by the Great Falls City-County Planning Board, Great Falls, Montana. The Corps of Engineers will provide interpretation and technical assistance, if requested, in application of the report data. Other guidelines available from the Corps of Engineers are a pamphlet, "Guidelines for Reducing Flood Damages" and a booklet, "Introduction to Flood Proofing".

BACKGROUND INFORMATION

Settlement

With the Lewis and Clark expedition camped at the mouth of the Marias River on their way up the Missouri River, Captain Meriwether Lewis led a small group upstream to find a portage around rapids and waterfalls on the Missouri River which the Indians had described to them. On 13 June 1805 Lewis got his first glimpse of the great falls for which the present nearby city is named. On the next day, alone, he proceeded upstream to the mouth of the Sun River (then called Medicine by the Indians) and for some distance west along that stream.¹

It was 74 years later when Paris Gibson chanced to read an account of the Lewis and Clark expedition and conceived the idea of local industrial development based on power from the falls. Many settlers had come and gone in the intervening years but when Gibson and others explored the site in 1882 only one, Lucas Caranza, remained. The Gibson party obtained land rights and surveyed a townsite; Great Falls is unique among cities in that, when new, wide streets, room for parks, and railroad right-of-way and yards were all plotted before building began. Nearby coal beds were a further inducement to these pioneers. The year 1884 saw extensive building, 1885 the first newspaper, and a grand ball. In March 1885 celebrated the completion of the first flour mill. The first railroad arrived in 1887 to serve a thriving community of 1,200. A silver-lead smelter began operation in 1888; in 1890 the local meat-packing industry was organized. Great Falls has further developed into a banking, commercial, and agricultural center.²

The Stream and Its Valley

The Sun River basin, in west central Montana, drains about 2,020 square miles between the river headwaters at the Continental Divide and

¹ Information from Lewis and Clark Journals.

² From "Great Falls Yesterday" a Work Progress Administration Writer Project Supervised by Edith R. Maxwell.

at Great Falls where the Sun River enters the Missouri River. The basin lies mostly within the semi-arid zone but average annual precipitation varies from about 13 inches on the plains to the east and up to 30 inches in the high mountains on the west. Elevations in the basin range from 3,300 feet, mean sea level (m.s.l.) to 9,500 feet m.s.l. in the mountains. Temperatures in the basin range from above 100 degrees to less than -50 degrees. Average Sun River channel slope is 23 feet per mile for the total basin and 10 feet per mile in the eastern portion. Gibson Reservoir, about 60 miles upstream from Great Falls, is used for irrigation and has only incidental flood storage. An irrigation diversion dam is located about 4 miles downstream from Gibson Reservoir. A map of the Sun River basin is located facing the Preface to this report.

The valley of the Sun River at the study reach is 1 to 1.5 miles wide and is bordered by plateaus 200 to 300 feet above the flood plain. The study reach extends from the mouth of the Sun River to a point 9.3 miles upstream at the west edge of Section 1, T20N, R2E, which is the jurisdictional boundary of the City-County Planning Board. The average channel slope in the study reach is .53 feet per mile. The channel in the study reach ranges from 180 to 440 feet wide and from 12 to 28 feet deep. The channel is quite sinuous. Channel capacity is about 12,000 cubic feet per second (c.f.s.). Intermittent levees have been built by local people along the Sun River. Photographs on the following pages illustrate channel conditions on the Sun River in the study reach.

Development in the Flood Plain

Great Falls has developed in all directions from the juncture of the Missouri and Sun Rivers. Most of the city, including the main business district, lies east of the Missouri River and safe from flooding. Great Falls economy is solidly based on manufacturing, trade, agriculture, lumber and tourism. Food, petroleum and coal, stone and clay, and metal goods are all products of the area.

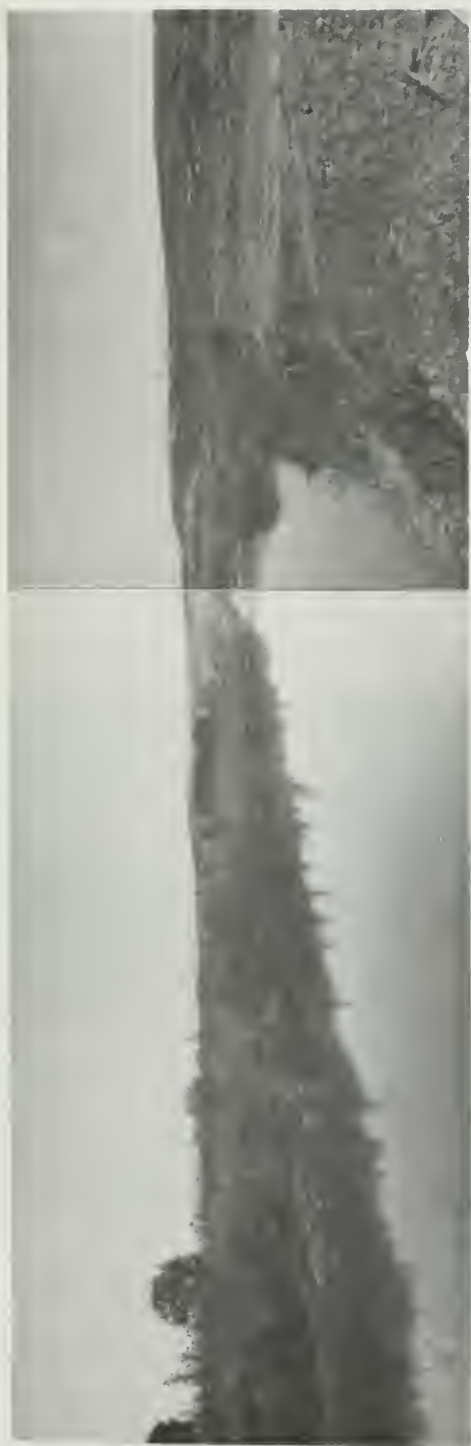


Figure 1. Sun River View Upstream Near Upper Limit of Study.



Figure 2. Sun River, Upstream of Central Avenue West Bridge.

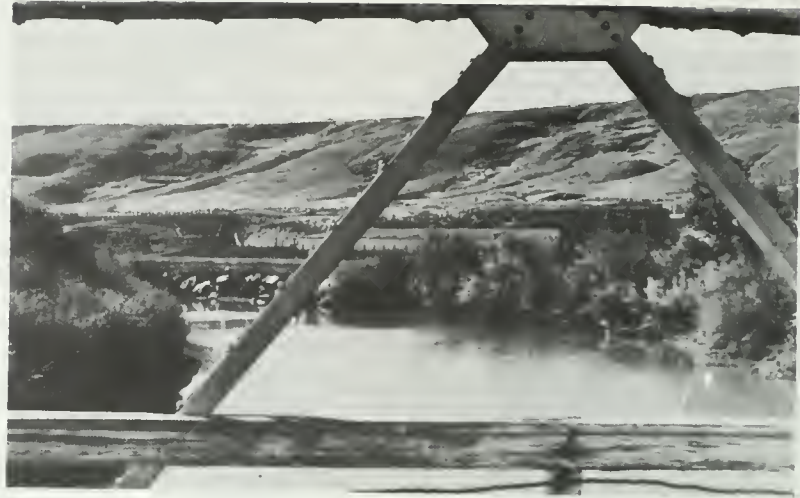


Figure 3. Sun River Downstream from
Central Avenue West Bridge.



Figure 4. Sun River View Downstream from Near 2nd Avenue S.W.



Figure 5. View Upstream to Interstate Hwy. Bridge, Sun River.



Figure 6. View Upstream from Bridge at 14th Street S.W., Sun River.



Figure 7. View Upstream to Railroad Bridge, Sun River, Great Falls.



Figure 8. Sun River, Upstream Side of 6th Avenue S.W. Bridge.

Much of that portion of Great Falls lying west of the Missouri River is in the Sun River flood plain. Medium and high-priced residential areas, factories and small business establishments, railroad yards and shops, country club and golf course, and apartment developments are located there. There is room for further development in the Sun River flood plain and, unless controlled, this will probably occur. However, the 9 percent population growth in Great Falls during the 1960's was considerably less than the 33 and 25 percent of the 1940's and 1950's. Table I presents U. S. Census Bureau figures for Great Falls and Cascade County since 1930.

Table I
POPULATION TRENDS

<u>Year</u>	<u>Great Falls</u>	<u>Cascade County</u>
1930	31,697	41,146
1940	33,395	41,999
1950	44,278	53,027
1960	55,357	73,418
1970	60,091	81,804

FLOOD SITUATION

Sources of Data and Records

There are no stream gages on the Sun River in the study reach. The U. S. Geological Survey has maintained a surface water recorder at Vaughn, Montana, 13 miles upstream from the mouth of the Sun River, since 1934. The Vaughn gage, measuring a drainage area of 1,854 square miles, is located on the basin map facing the Preface. Gage records at Vaughn were taken from U. S. Geological Survey Water-Supply Paper No. 1679 and from annual records.

Most of the information on past floods was obtained from Corps of Engineers flood records. Flood accounts in Montana newspapers such as the Great Falls Tribune and Billings Gazette were a valuable source of information. Photographs used in the report are by Corps of Engineers personnel.

Detailed channel and valley cross sections, surveyed by the Corps of Engineers in 1965, were used to compute flood profiles. Flooded area outlines were first plotted on 2 foot interval contour maps made by photogrammetric methods from aerial photos made for the Corps of Engineers under contract in April 1965 and, where these were unavailable, onto 10 foot contour U.S.G.S. quadrangle maps. The flooded areas were then transferred to aerial photographs made by A.S.C.S. in 1966.

Flood Season and Flood Characteristics

Flooding occurs along the Sun River at Great Falls when rainstorms occur at the same time as the heaviest snowmelt in May and June. This does not exclude the possibility of a flood caused by a major rainfall event later in the summer. Peaking time for flows in the Sun River at Great Falls after a heavy rainstorm in the river basin varies considerably depending on the concentration of rainfall in the basin and the degree of surface soil saturation prior to the storm event. The storm that produced flooding in 1964 was centered near the extreme upper portion of the basin and basin soils were very wet from prior general rains causing a high rate of runoff. The 1964

flood peaked at Great Falls in about 24 hours. Duration of flooding is dependent on the rate of snowmelt runoff and the coincident rainfall runoff in the basin, both factors strongly contributed to the severity of the 1964 flood.

Factors Affecting Flooding and Its Impact

Obstructions to flood flows - Five bridges cross the Sun River within the study reach. Of these, only the 6th Street bridge restricts flood flows causing a significantly higher flood elevation upstream than downstream from the bridge. Some raised roadway embankments guide overbank flows, as illustrated by the Interstate 15 and Great Northern railroad embankments shown on Plate 3, but do not raise water surfaces due to other hydraulic factors. Floating debris can collect at bridges thus raising water levels upstream of the bridge but this unpredictable factor is not considered in this report. The degree of overbank flow obstruction due to vegetation and buildings in the flood plain was considered in the hydraulic computations.

Flood damage reduction measures - There are no major flood control structures in the Sun River basin. Gibson Dam provides slight incidental reduction in flood peak discharges. Local officials at Great Falls have expressed strong interest in flood control measures after damaging floods in 1953 and 1964. The Omaha District, Corps of Engineers has recommended a plan calling for levees on both banks of the Sun River, bridge alterations, and a diversion ditch to handle storm runoff from hills to the north. The project has not been built due to various difficulties at the local level. There is no city or county ordinance to regulate flood plain development in the study reach. There is no evidence of flood proofing of structures in the flood plain.

Other factors and their impacts - A portion of the Sun River flood plain is common with the Missouri River flood plain. Adequate preliminary flood warning at Great Falls is not a particular problem; slow response by residents of the flood plain to warnings of potential

flooding could add to flood damages and add hazard to evacuation activities. Material storage on the flood plain is not a problem at Great Falls.

Flood warning and forecasting - The National Oceanic and Atmospheric Administration (NOAA), National Weather Service provides flood forecasting service for major river basins. Stage forecasts for the Sun River are based on radar coverage, reports from five river stations, and about six rainfall reporting stations in or near the basin. Flood forecasts are transmitted to city officials, newspapers, and to radio and television stations. These media disseminate the information to residents of the flood plain. Past floods at Great Falls were predicted 24 hours or more in advance; normal lead time from forecast to flood crest is about 42 hours for a rainfall event. A storm centered in the east portion of the basin could reduce lead time to less than 24 hours. During the 1964 flood, however, slow response to warnings by residents of the flood plain was something of a problem. This was also a factor in the recent disastrous flood at Rapid City, South Dakota, where warning time was much less and slow reaction to warnings was much more critical in terms of loss of human life.

Flood fighting and emergency evacuation plans - During the 1964 flood at Great Falls, local officials, police and firemen, military personnel, and many volunteers worked magnificently to protect human life and to reduce flood damages in the Sun River flood plain. The local Civil Defense office, as a part of total City-County emergency planning, has since developed warning and evacuation procedures to be used during future floods. Emergency flood action is in two phases, (1) property evacuation and (2) total evacuation of people from the flood plain, with the latter phase to commence 6 hours prior to the estimated flood crest arrival at Great Falls. Plans include established emergency traffic patterns and control, recording of people moving in and out of flood prone areas, provision for temporary shelters and property storage facilities, and for standby emergency vehicles such as boats and military helicopters for surveillance and rescue.

Material storage on the flood plain - Often floatable material stored on the flood plain is washed away during flooding to collect at points downstream and impede flood flows. The Sun River flood plain is relatively clean of such material, or debris, and no problems in this respect are anticipated.

PAST FLOODS

Summary of Historical Floods

During early floods on the Sun River at Great Falls the western portion of the city was largely undeveloped and floods did not cause extensive urban damage there. Records at the Sun River gage near Ft. Shaw, Montana, and about 30 miles from Great Falls, show a peak discharge of 27,200 cubic feet per second there on 7 June 1908. This flood may have been the second largest at Great Falls. Flow records at Ft. Shaw, about 35 miles upstream from Great Falls, show peaks of 20,000 cubic feet per second on 21 June 1916 and 16,400 cubic feet per second on 26 May 1917. Both the Sun River gage near Ft. Shaw and the Ft. Shaw gage have since been discontinued. Floods during which known damages occurred on the Sun River at Great Falls occurred in 1948, 1953, and 1964. At frequent intervals heavy local rains cause shallow flooding from storm runoff from the hills north of the study reach. Such a flood in 1938 damaged basements, yards, gardens, outbuildings and roads.

Flood Records

There are no direct streamflow records on the Sun River at Great Falls. Table 2 presents flood peak discharges at Vaughn, Montana and is indicative of peak flows in the study reach. Flows are partially regulated by irrigation diversions upstream of Vaughn. Local newspapers and Corps of Engineers field notes contain narrative accounts of past floods. The outline of the 1964 flooded area is well defined in Corps records by aerial photographs, some of which are reproduced in this report.

Table 2
HISTORIC FLOOD PEAK DISCHARGES
SUN RIVER AT VAUGHN, MONTANA

<u>Year</u>	<u>Date</u>	<u>Maximum Discharge c.f.s.</u>
1948	June 6	14,300
1953	June 4	17,900
1964	June 9	53,500

Flood Descriptions

4 through 18 June 1948 - Early in June 1948 the snow pack in the headwater area of the Sun River basin was estimated to be twice the normal amount for that time of year and daily temperatures were above average. These conditions resulted in higher than normal runoff conditions on the mountain tributaries. General rainfall occurred in the basin from 2 through 5 June, with 3.93 inches recorded in the Gibson Dam area. Sun River flooding resulted from Augusta to the mouth for various periods of time from 4 through 18 June 1948. The peak discharge at the Vaughn gage was 14,300 cubic feet per second on 6 June. The western portion of Great Falls began to flood on 4 June and continued through 18 June. Initial flooding from 4 to 9 June was caused by overbank flow of the Sun River while later flooding resulted from backwater from the Missouri River. About 68 residences were damaged by first floor flooding. Most streets and roads in the area were closed for several days during this flood. Photographs of the June 1948 flood at Great Falls are reproduced on the following pages.

May and June 1953 - Prolonged rainfall over the basin from 23 May to 4 June 1953 caused flooding along the Sun River from near Augusta, Montana to the mouth. The peak discharge at Vaughn was 17,900 cubic feet per second at 1:00 p.m. on 4 June. This flood damaged 177 residences and 7 businesses in Great Falls. All vehicular traffic in the area was disrupted. A total of 546 people were evacuated in the western portion of Great Falls.

7 through 13 June 1964 - Northwestern Montana experienced the worst natural disaster in the history of the state during the period 7 through 13 June 1964. Heavy rainfall on 7 and 8 June centered near the Continental Divide together with high snowmelt runoff caused unprecedented flooding in the Sun and Marias River basins. Snow surveys in early May indicated that snowpack in the mountains was 150 to 200 percent of normal, and greater than normal May rains had saturated soils and filled reservoirs. Severe flooding occurred throughout the

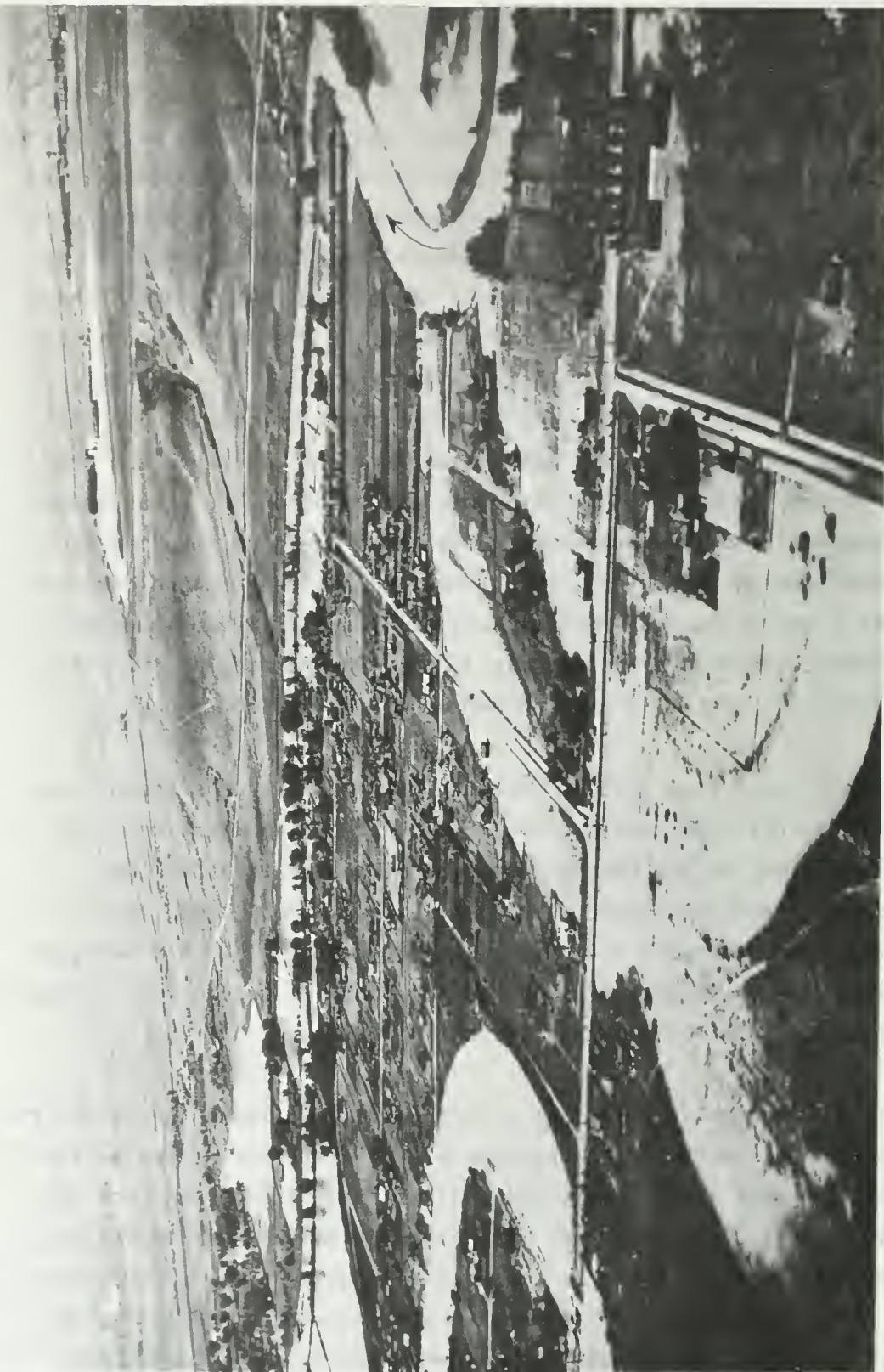


Figure 9. 6 June 1948, Aerial View to South, Flooding on West Side of Great Falls.



Figure 10. 6 June 1948, Aerial View to South, Flooding on West Side of Great Falls.

Sun River basin, beginning early on 8 June in the headwaters of the Sun River and cresting at Great Falls near midnight on 9 June. The peak discharge at the Vaughn gage was 53,500 c.f.s. The 14th Street bridge was pounded by water-borne debris but held despite fears that the structure would collapse. A natural gas line was ruptured on the 6th Avenue bridge. Surveyed high water marks for the 1964 flood are shown on plates at the back of this report.

News of flooding in the upper basin spread swiftly and the Red Cross, Civil Defense, National Guard, Office of Emergency Planning, and Corps of Engineers were quickly on the scene to organize evacuation, flood fighting, and cleanup. Although Civil Defense organization was begun early in the morning of 9 June and a map of areas of Great Falls likely to be flooded had been charted by 1:30 p.m. the same day, it was difficult to get residents of the hazard areas to leave. City officials went on local radio and television with warnings and others went from house to house in the flood plain but it was reported that their warnings went largely unheeded until "as the water rose more and more people realized that they would be flooded - - - and - - - the calls (for assistance) started hitting us all at once."¹

Flooding in the western part of Great Falls resulted from overflow of both the Sun and Missouri Rivers. Flood damage at Great Falls from both streams was estimated at over \$4 million. Approximately 3,000 persons were evacuated from the flooded areas and boarded in 11 hastily organized shelters. Varying degrees of damage were sustained by 681 homes and 24 businesses. A local survey later indicated that 518 families suffered 50 percent or more loss of personal possessions and of this number, 350 families lost 100 percent of their personal belongings. Damage to the Great Falls sewer system was great and the return of many evacuees to their homes was postponed for several days until sewer repairs could be made. A week after the flood 85 persons were still in temporary shelters. Total damages in the Sun River basin were estimated at near \$9 million. Photographs on the following pages illustrate the magnitude of the 1964 flood

¹ Billings Gazette, 17 June 1964

at Great Falls when flood outlines on the photographs are compared with those on Flooded Area maps on Plates 2 and 3. High water marks for the 1964 flood are shown on Plates 3 and 4.



Figure 11. Rural Area Upstream of
Great Falls, June 1964.



Figure 12. Great Falls, 10 June 1964.



Figure 13. 1964 Flood - High Water Mark.



Figure 14. 1964 Flood - Foundation Damages.

FUTURE FLOODS

Two large potential floods, the Intermediate Regional and Standard Project Floods, were developed to study the effect of large floods on the Sun River study reach at Great Falls. The Intermediate Regional Flood is one with an average frequency of occurrence of about once in 100 years and has generally been accepted by the public as a minimum limit for application of local regulations. The Standard Project Flood is larger and represents a reasonable upper limit of expected flooding.

Intermediate Regional Flood

The discharge-frequency relationships for the Sun River at Great Falls were determined by statistical analyses of streamflow records at Vaughn, Montana and of the runoff data gathered during the June 1964 flood. The Intermediate Regional Flood discharge on the Sun River at Great Falls is 39,000 c.f.s.

Standard Project Flood

The Standard Project Flood is presented in this report as the practical upper limit of flooding. Storms that would produce this flood are uncommon, and it is difficult to assign frequencies of occurrence with any reasonable degree of accuracy. The Standard Project Flood discharge on the Sun River at Great Falls would be 65,000 c.f.s.

Frequency

Floods larger than the Standard Project Flood could occur. The June 1964 flood at Great Falls was of greater magnitude than the Intermediate Regional Flood as indicated by the maximum discharge at Vaughn of 53,500 c.f.s. An examination of historic peak discharges, however, shows that floods smaller than the Intermediate Regional Flood are much more common, with an average peak annual discharge of about 8,000 c.f.s. for the past 37 years.

Hazards of Large Floods

The effects of the Intermediate Regional and Standard Project Floods were studied to determine hazards caused by these potential floods in the Sun River flood plain at Great Falls. The analysis used field conditions represented by bridge and valley cross sections surveyed in 1965. Hazard factors include extent of area flooded, depth of flooding, obstructions to flood flows, velocities of floodflows, rate of rise of stream level, and duration of flooding.

Flooded area and flood damages - The areas in Great Falls that would be flooded by the Sun River during the Intermediate Regional or Standard Project Floods are shown on Plates 2 and 3. Water surface profiles for these floods were determined using backwater computations employing the Standard Step Method. The profiles on Plate 4 show the depth of flooding in the channel and the elevation of the water surfaces over the adjacent flood plain. Head losses at bridges were computed using data in "Hydraulics of Bridge Waterways" published by the U. S. Department of Commerce. Flood outlines were determined by projecting water surface elevations to the surveyed flood plain. Plates 5 and 6 portray cross sections across the channel and valley and show ground elevations and depths of overbank flooding. Reference points are used to locate flood elevations at intervals along the Sun River; these points coincide with surveyed cross sections used in the study. The reference points are located on both the "Flooded Area" plates and the "Profile" plates. Table 3, page 28, lists reference point data including elevations of the streambed and the Intermediate Regional and Standard Project Floods. Depths of flow for the Intermediate Regional and Standard Project Floods can be estimated from the profiles, cross sections, or reference table. Where accuracy is needed to delineate flooded area, the appropriate flood elevation can be taken from one of these sources and compared to a surveyed ground point elevation in the flood plain.

Upstream from Central Avenue West bridge most of the area inundated by large floods is agricultural land, with only occasional

residences and various storage buildings. Large areas on both banks are flooded in this reach. A large residential area on the left bank would be flooded downstream from Central Avenue West bridge to the mouth of the Sun River. Warehouses and other industrial and commercial facilities would be flooded in the triangular rail yard area north of the Great Northern railroad bridge. Right bank flooding is minimal downstream from Central Avenue West bridge, affecting mostly a sparsely developed area on both sides of Interstate Highway 15. The depths of potential floods at specific locations in the Sun River flood plain are shown by photographs on the following pages.

Obstructions - On the Sun River at Great Falls there are obstructions to floodflows both in the channel and on the flood plain. There are five bridges in the study reach; of these, the 6th Street bridge has the greatest effect on water surface profiles of large floods. During floods, debris can pile up against bridges, as it did in 1964 at the 14th Street bridge, and result in higher water upstream due to constricted water passageway or damage to the bridge from pressure. Debris at the bridges is not considered during preparation of water surface profiles because this is an indeterminate factor. The flooded area maps and water surface profiles show the effect of known constrictions and structures but do not reflect other factors such as debris or deposition of silt under bridges. Raised roadways on the flood plain as well as houses and other buildings in the flood plain will also tend to obstruct flows.

Velocities of flow - Fast moving floodwaters create hazards during potential floods at Great Falls. Velocities of 3 feet per second with depths of 2 feet or more are considered dangerous. Overbank flow velocities upstream from the Interstate highway during large floods will average less than 3 feet per second although higher velocities will occur at random locations. Higher velocities, averaging greater than 3 feet per second, will occur downstream from the Interstate.



Figure 15. Depth of Potential Floods -
10th Avenue S.W. and
Crescent Drive.



Figure 16. Depth of Potential Floods -
10th Avenue S.W. and
14th Street S.W.



Figure 17. Depth of Potential Floods -
5th Avenue S.W. and West of
21st Street S.W.

Rate of rise and duration of flooding - Flows in excess of channel capacity, as measured at Vaughn, have occurred 3 times during the past 37 years. The rate of rise, or peaking time, of future large floods is 24 hours or greater at Great Falls. Duration of flooding can last for several days.

GLOSSARY OF TERMS

Backwater

The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood

An overflow on lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river or stream or an ocean, lake or other body of standing water.

Normally a flood is considered as any temporary rise in stream flow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased stream flow, and other problems.

Flood Crest

The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Plain

The relatively flat area or low lands adjoining the channel of a river, stream or water course or ocean, lake or other body of standing water, which has been or may be covered by floodwater.

Flood Profile

A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to

show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage

The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Head Loss

The effect of obstructions, such as narrow bridge openings or buildings that limit the area through which water must flow, raising the surface of the water upstream from the obstruction.

Intermediate Regional Flood

A flood having a one percent probability of occurrence in any year or an average frequency of occurrence in the order of once in 100 years. The flood may occur in any year. It is based on statistical analyses of stream flow records and analyses of rainfall and runoff characteristics in the general region of the watershed.

Left Bank

The bank on the left side of a river, stream or water course, looking downstream.

Reference Point

A numbered point identifying a specific location for correlating the data shown in various forms throughout the report.

Right Bank

The bank on the right side of a river, stream, or water course, looking downstream.

Standard Project Flood

The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably

characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40 percent to 60 percent of the Probable Maximum Floods for the same basins. Such floods, as used by the Corps of Engineers, are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Top of Waterway

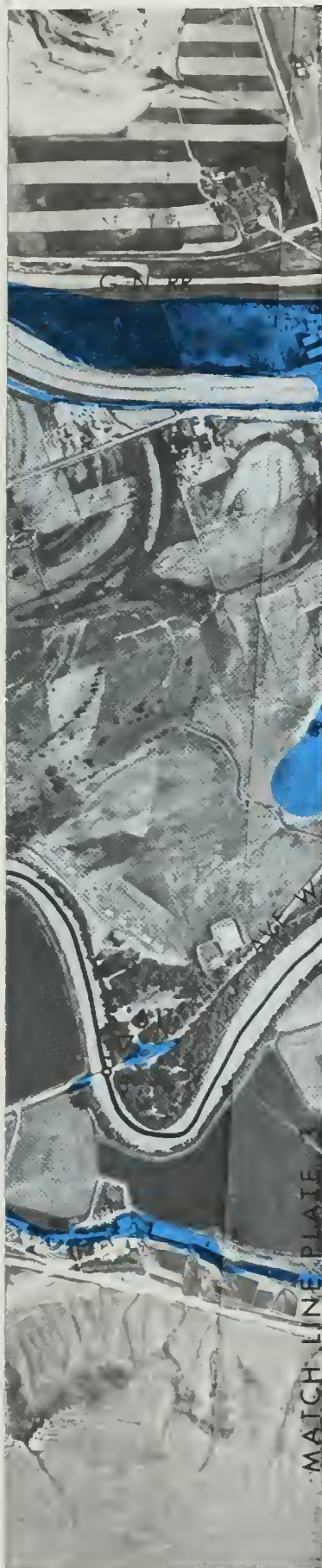
This is the roof of the opening in a stream crossing through which water flows under normal conditions. It is the underside of the deck span - sometimes called "low steel," the roof of a box culvert or the crown of an arched or circular culvert.

Table 3
FLOOD PLAIN REFERENCE DATA
SUN RIVER

Identification	Reference Point	Distance From Mouth Feet	Stream Bed Elevation Ft. M.S.L.	Intermediate Regional Flood Elevation Ft. M.S.L.	Standard Project Flood Elevation Ft. M.S.L.
Upstream Limits	1	49,000	---	3332.6	3335.7
	2	43,900	3305.0	3331.0	3334.2
Cross Section 1-1	3	33,990	3289.5	3328.7	3331.9
	4	28,490	3304.8	3328.0	3331.3
Central Ave. West	5	26,120	3298.5	U/S 3327.1 D/S 3327.1	U/S 3330.9 D/S 3330.9
	6	22,460	3302.2	3326.6	3330.6
Cross Section 2-2	7	13,960	3303.4	3325.5	3329.7
1-15	8	10,185	3297.6	U/S 3324.8 D/S 3324.2	U/S 3329.4 D/S 3328.2
14th Street	9	6,300	3303.0	U/S 3322.1 D/S 3322.0	U/S 3326.2 D/S 3326.1
Great Northern RR	10	5,200	3294.3	U/S 3321.1 D/S 3321.0	U/S 3325.5 D/S 3325.3
6th Street	11	3,570	3300.3	U/S 3320.8 D/S 3319.1	U/S 3325.1 D/S 3322.4
	12	3,180	3291.6	3318.9	3322.3
Cross Section 3-3	13	1,110	3300.6	3318.1	3321.1
Mouth		0	3298.3	3317.2	3320.0

U/S Upstream Side of Bridge

D/S Downstream Side of Bridge



LEGEND:

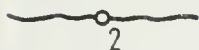


INTERMEDIATE
REGIONAL FLOOD

STANDARD
PROJECT
FLOOD



Channel and Valley
Cross Section



Reference Point - Also locations
of surveyed cross sections



High Water Mark (HWM)

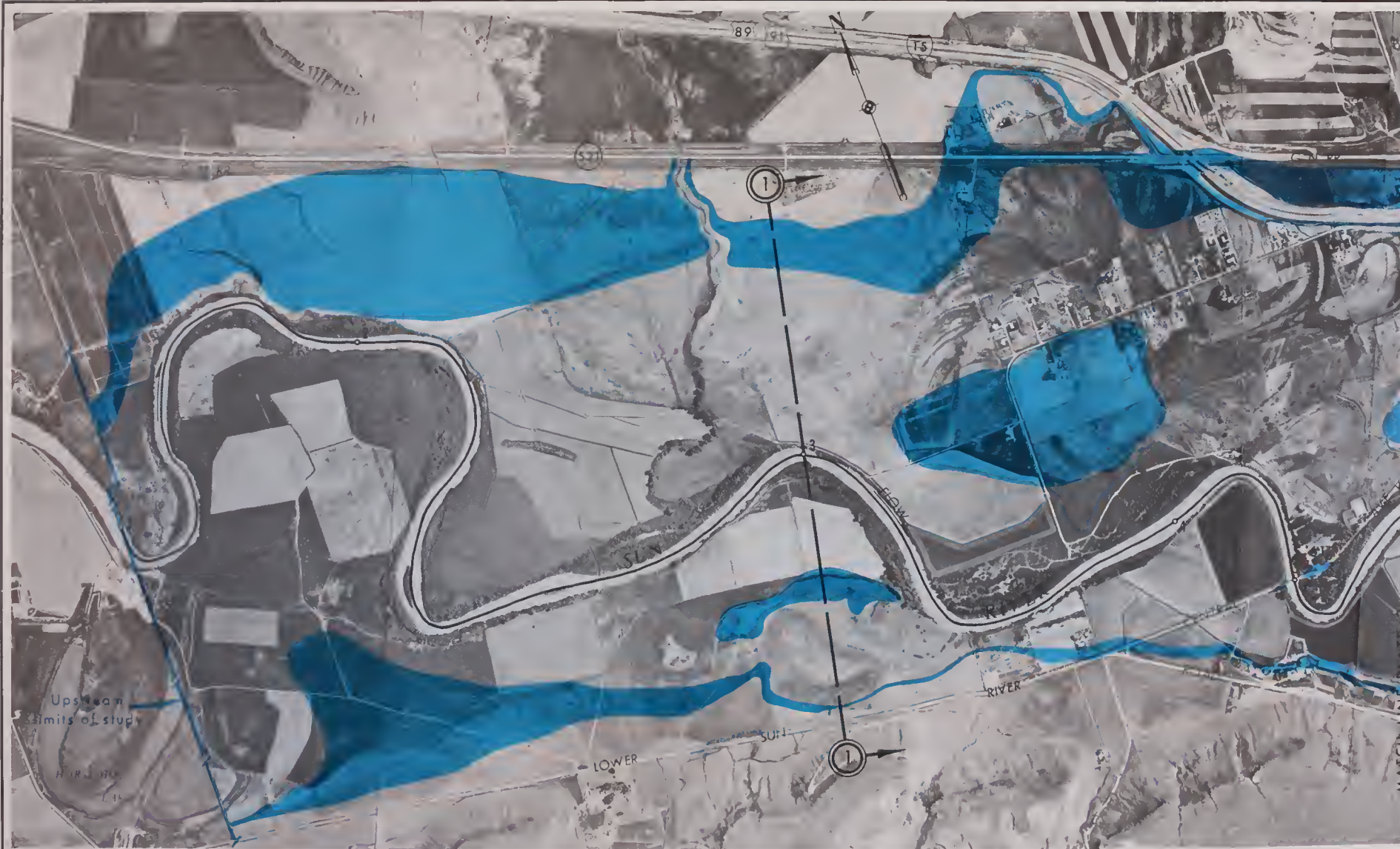
NOTES:

1. For Illustrated Cross Sections, see Plates 5 & 6.
2. For Profile, see Plate 4.
3. For flood elevations at the reference points, see Table 3.
4. Flooding shown in Missouri River Flood Plain only for Sun River flows. Flooding for Missouri River flows may be different.
5. For elevations at HWM, see Profile Plate 4.

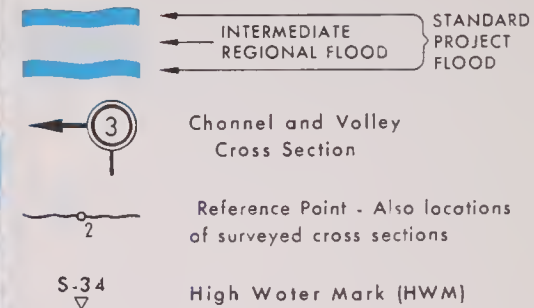


SUN RIVER BASIN GREAT FALLS, MONTANA SUN RIVER FLOODED AREAS

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEBRUARY 1973



LEGEND:



NOTES:

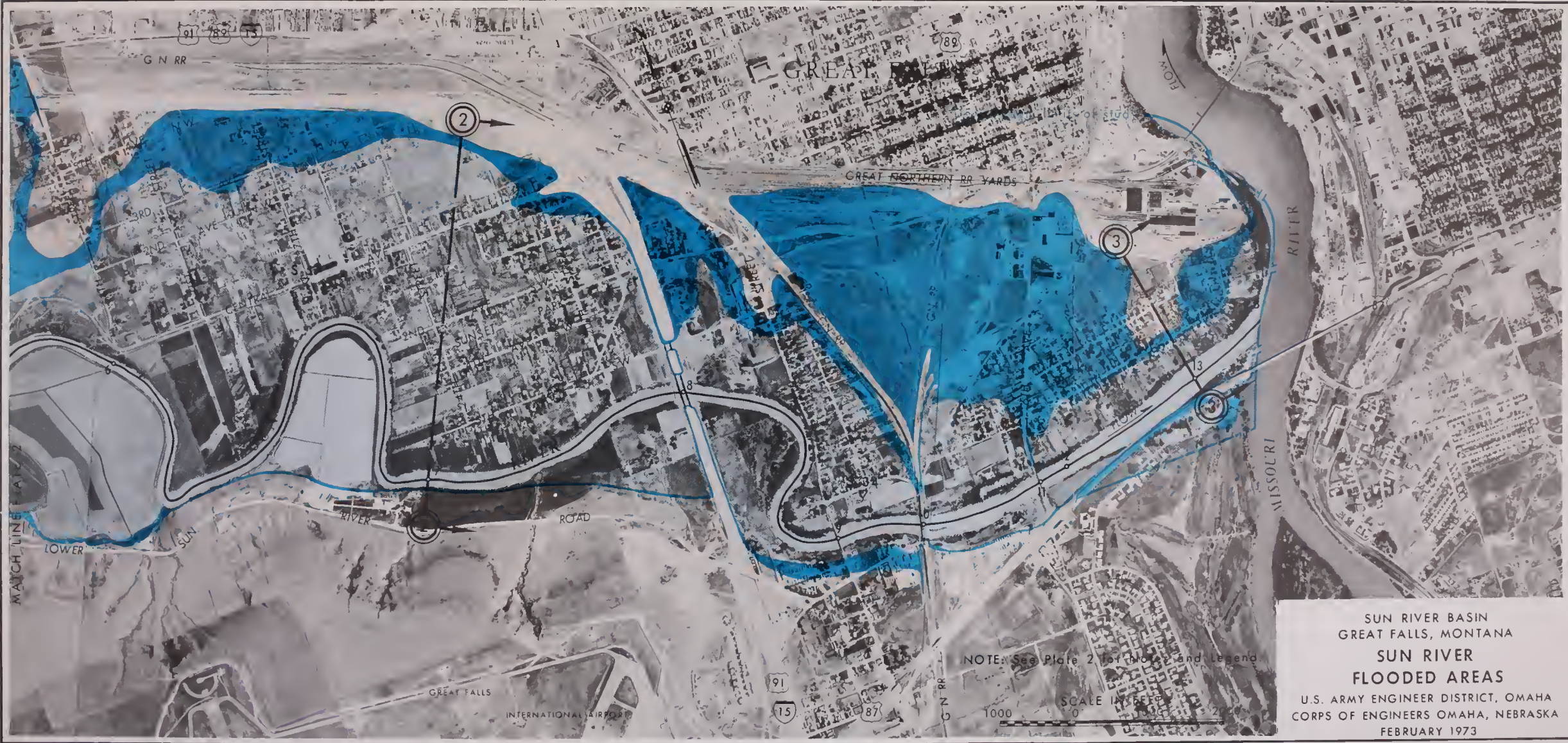
1. For Illustrated Cross Sections, see Plates 5 & 6.
2. For Profile, see Plate 4.
3. For flood elevations at the reference points, see Table 3.
4. Flooding shown in Missouri River Flood Plain only for Sun River flows. Flooding for Missouri River flows may be different.
5. For elevations at HWM, see Profile Plate 4.



SUN RIVER BASIN
GREAT FALLS, MONTANA

SUN RIVER FLOODED AREAS

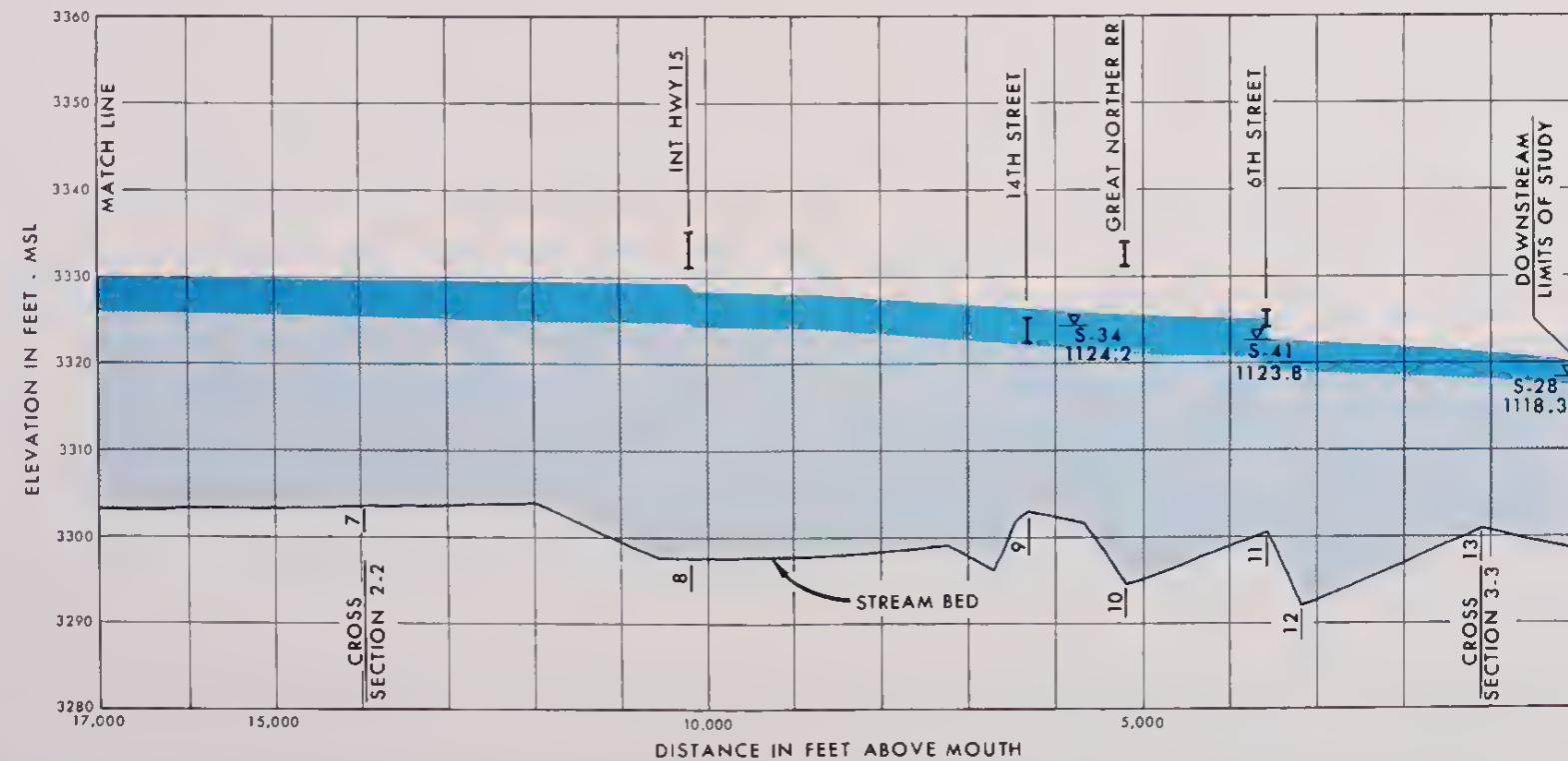
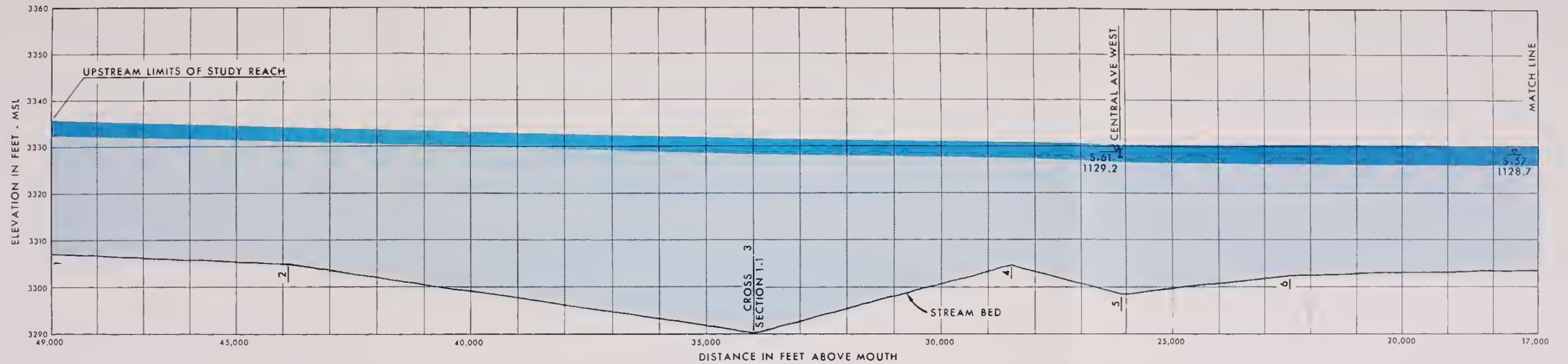
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEBRUARY 1973



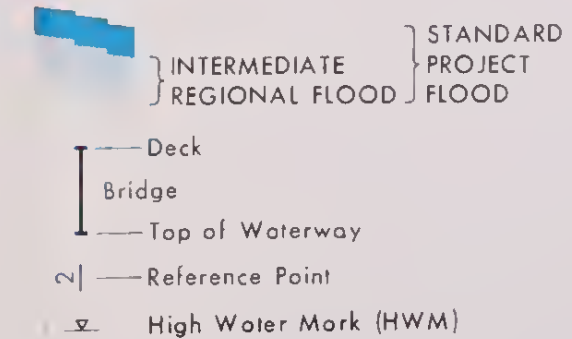
SUN RIVER BASIN
GREAT FALLS, MONTANA

**SUN RIVER
FLOODED AREAS**

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEBRUARY 1973



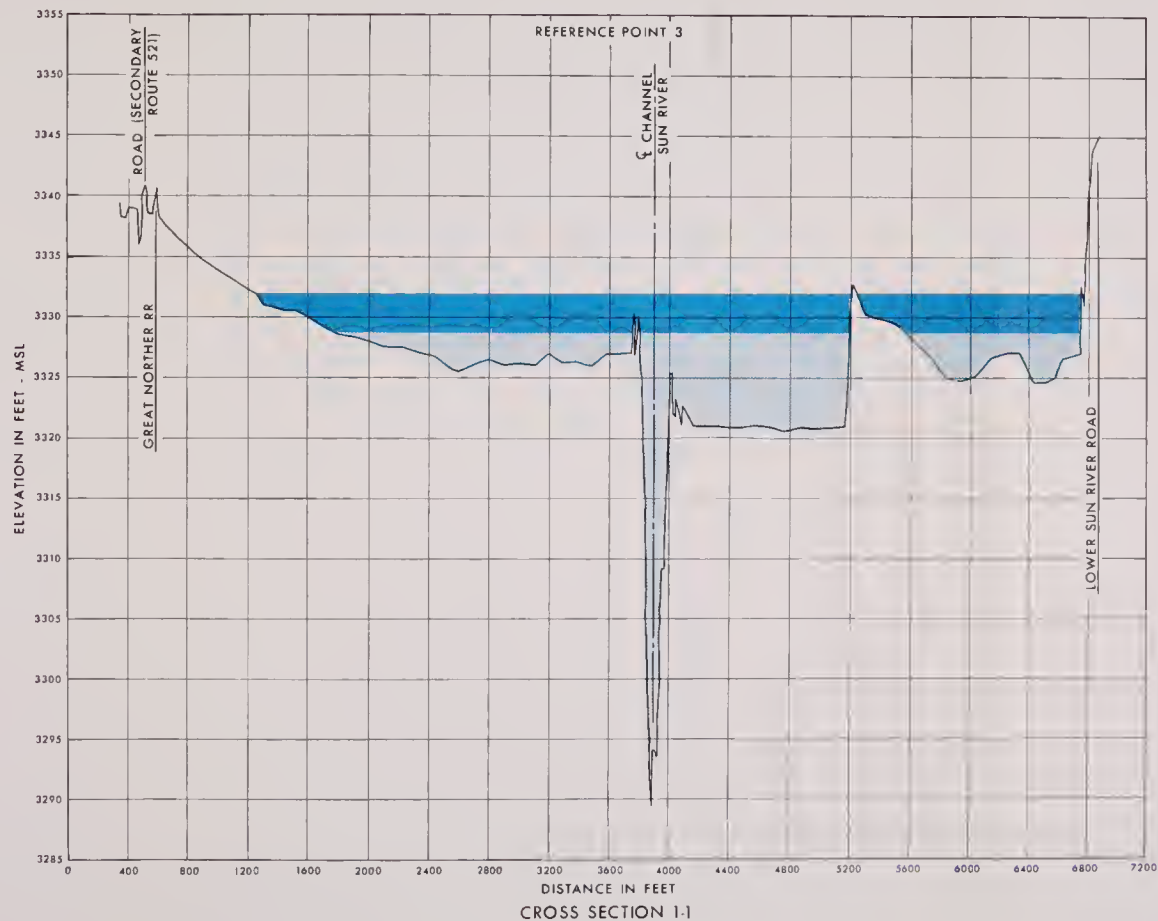
LEGEND:



NOTES

1. For location of Cross Sections, see Plates 2 & 3
2. For Illustrated Cross Sections, see Plates 5 & 6
3. For flood elevations at the reference points, see Table 3
4. For location of HWM see Plates 2 & 3

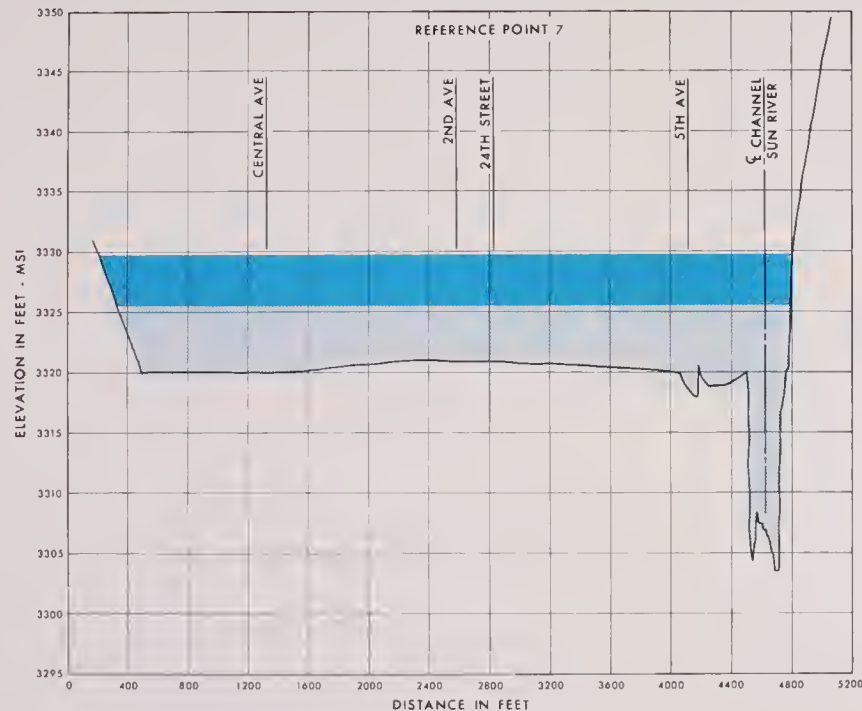
SUN RIVER BASIN
GREAT FALLS, MONTANA
SUN RIVER
PROFILE
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEBRUARY 1973



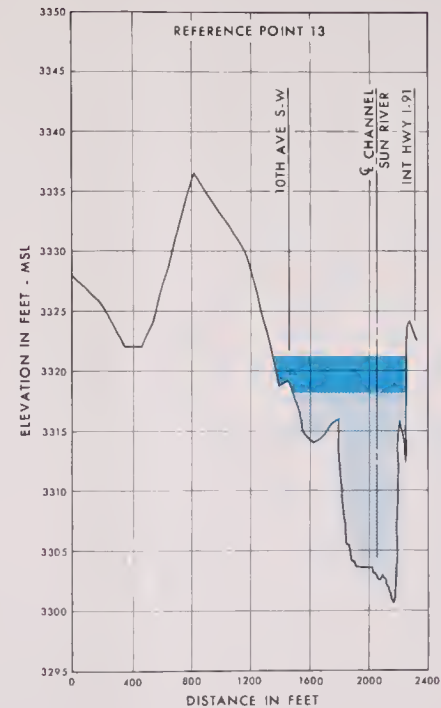
NOTES

1. For location of Cross Section, see Plate 2

SUN RIVER BASIN
GREAT FALLS, MONTANA
**SUN RIVER
CROSS SECTION**
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEBRUARY 1973



CROSS SECTION 2-2



CROSS SECTION 3-3



NOTES:

1. For location of Cross Section, see Plate 3.

SUN RIVER BASIN
GREAT FALLS, MONTANA
SUN RIVER
CROSS SECTIONS
U S ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
FEBRUARY 1973

